Climate Test Bed (CTB) Seminar Series Presents

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Why Is the Stratosphere More Predictable and What Are the Implications for the Seasonal Predictions of the Troposphere?

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Abstract

The global mass circulation links the tropics to the extratropics and the stratosphere to the troposphere. Such a global mass circulation consists of three distinct but inter-connected thermally direct circulation cells: the tropical Hadley cell, the stratospheric cell, and the extratropical Hadley cell. Collectively, these circulation systems move warm air poleward aloft and cold air equatorward near the surface, forming a broad thermally direct circulation in each hemisphere. In the extratropics, the mass circulation is carried out mainly by baroclinically amplifying (or westward tilting) Rossby waves. The westward tilting waves are responsible for a net poleward mass transport aloft and equatorward mass transport below. The stratosphere is the integral part of the warm air branch of the global mass circulation. Based on the mass circulation theory, we will show that as long as the westward tilting of planetary waves in the stratosphere and their overall amplitude can be captured, the CFSv2 forecasts would still be very skillful in predicting zonal mean anomalies even though it cannot do so for the exact locations of planetary waves and their spatial scales. In particular, the CFSv2 is capable of predicting mid-winter polar stratosphere sudden warming events in the Northern Hemisphere and the timing of the final warming polar stratosphere warming in both hemispheres 3-4 weeks in advance.

The temporal and spatial variation of the warm air branch in the stratosphere is synchronized with the cold air branch in the troposphere below. Because the pole is the destination point of the warm air branch and the beginning point of the cold air branch, the synchronized poleward warm air advancement and equatorward cold air movement would lead to a strong stratosphere-troposphere coupling over the polar region. Such stratosphere-troposphere coupling via mass circulation is a new source of the prediction skill for intra-seasonal to interannual climate variability.

The cold air mass is effectively imprisoned within the polar cap when the mass circulation is weaker, responsible for warm surface temperature anomalies prevailing in the extratropics. The stronger warm air branch of the mass circulation aloft requires a strengthening of the compensating equatorward advancement of the surface air mass, causing massive cold air outbreaks in the extratropics.